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ABSTRACT

Studies examining the topics of attitude and achievement, attitudes of males and females, and grade level and gender have produced a variety of inconsistent or weak results. This study investigated elements of science classrooms that are influential in forming the attitudes of students. The study used projective and cross-sex probes in two new types of measures: the projective response and the sentence-completion test. A 40 item classroom structure scale was created and given to students in 40 classrooms in grades 2, 5, 8, and 11 (n=1,084). From these classes, two student-centered and two teacher-centered classrooms were chosen and were administered the instrument "Individual and Group Attitudes Toward Science." Ten students were randomly chosen from each classroom to complete a sentence completion test. Results confirm that attitude toward science decline as students get older. The most prominent finding is that students express better attitudes toward science than they believe others hold, and better than they believe their parents hold. Teachers were most disliked in the eighth grade and in teacher-centered classrooms. (PR)

An Investigation of Projective Measures of Attitude Toward Science

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An Investigation of Projective Measures of Attitude Toward Science

Introduction

The impetus for the research of which this study is a segment arises from a general concern with available measures of attitude toward science. Lack of theoretical constructs, scale items mismatched with scale construct, and scales grouping items tapping several dimensions but treated as uni-dimensional, are but a few of the conceptual and psychometric problems to be dealt with (Gardner, 1975). An additional problem, discussed by Rennie and Parker (1987), is the fact that results are often counfounded by a failure to control for grade level and sex differences in response to attitude measures. One consequence is that studies examining attitude and achievement (Steinkamp and Maehr, 1983), attitudes of males and females (Wilson, 1983), and grade level and gender (Fleming and Malone, 1983) have produced a variety of inconsistent or weak results.

Perhaps a more significant flaw is the degree to which attitude instruments are constructed from the perspective of the scholar rather than that of the person whose attitude is to be assessed. This is an issue of construct validity, and the question is whether it is possible in principle for valid attitude constructs to arise elsewhere than in the minds of those who hold the attitudes. Not to put too fine a point on it, it may be necessary to analyze the statements of students about

science in order to prepare appropriate measures of their attitudes.

Earlier studies in this research program relied entirely upon interviews with science students to identify salient aspects of their classrooms that contributed to attitude (Baker, Niederhauser and Piburn, 1989). These interviews revealed substantial grade-level effects, but little in the way of differences between the sexes . Since this went against the traditional wisdom (Levin, Sabar and Libman, 1991), an attempt was made to identify new techniques for further exploration of factors influencing attitude. One which seemed particularly promising was the use of projective techniques, such as asking students to answer both as self and as other, or cross-sex questioning in which they are asked to respond as they think a member of the opposite sex might. Dramatically different results with regard to self-esteem had been observed for boys and girls under these two conditions by Robinson-Awana, Kehle and Jenson (1986). A commonly held assumption underlying the use of projective techniques is that children attribute socially undesirable affect to ambiguous characters that they ordinarily do not to themselves (Brody and Carter, 1982).

The nature of the classroom itself appears to be a confounding variable of some significance in forming attitudes. Johnson and Johnson (1975) described the classroom as a "social milieu in which there are a variety of possible forms of social

interdependence that strongly affect its members both in terms of what is learned and how learning occurs" (pg. 104). For example, peer group friendships within the class have an impact upon students' self-concepts, attitude toward school, and academic performance. In addition, student-teacher interaction is often conducted within the context of student-peer groups (Johnson, 1970), and responses to a teacher's directive are influenced by the feelings, attitudes, and relationships shared within their student-peer group. Schmuck and Schmuck (1975) have defined this "property of groupness" as a collection of interacting persons with some degree of reciprocal influence over each other.

Several studies have examined the effects of environment on attitude. Talton and Simpson (1986) stated that classroom environment variables predicted the greatest amount of variance in attitude toward science in all grades. Simpson and Oliver (1990) found that across grades six to ten, class climate, other students, and friends were significant predictors of a student's attitude toward science. Results from the National Assessment of Educational Progress (Mullis and Jenkins, 1988) suggested that two classroom variables might be particularly important in determining attitude. These were the degree of competitiveness and and the locus of control between students and teacher. It was anticipated that girls would prefer more student centered and cooperative classrooms, and boys more competitive and teacher centered classrooms.

Research Design

The primary purpose of this study was to continue an investigation of the elements of science classrooms that are influential in forming the attitudes of students.

A major innovation in this study was the inclusion of projective and cross-sex probes in two new types of measures. The first was an attitude scale calling for projective responses, and the second was a sentence-completion test.

Finally, the variables of classroom structure and sex differences were controlled by balancing the design across two types of classroom and by distinguishing the responses of boys and girls.

Sample

A measure of classroom structure was created for this research. Appropriate items were extracted from the Individualized Classroom Environment Questionnaire, Learning Environment Inventory, My Class Inventory and Classroom Environment Scale (Fraser, B. and Fisher, D., 1983). After review by a group of college education students, 40 items that received high levels of endorsement were included in the measure.

This instrument was administered in 10 classes each at grades 2, 5, 8 and 11 (n=1084). A principle component analysis, followed by varimax rotation, revealed two major factors that were interpreted as a reflection of the locus of control over the

decision-making process in the classroom. The first indicates the degree to which students believe they are involved in making classroom policy. The second strongly suggests a great deal of teacher control, and perhaps a concomitant degree of competitiveness among students.

From among the 40 classes initially tested, two student-centered and two teacher-centered classrooms were chosen at each grade level for further study. A measure of Individual and Group Attitudes Toward Science was administered to all 408 students in those classrooms. In addition, approximately ten students, half boys and half girls, were chosen randomly from each classroom and asked to complete a Sentence Completion Test.

Attitude Measures

The use of the terms "I", "We" and "Other" in the attitude measure were intended to capture degrees of "groupness" that were experienced by individuals within classrooms. Many instruments that are used to assess attitudes stress only an individual's perspective on an area of interest. Since there are theoretical views that stress the interdependence of peers and attitudes within the classroom, a unique method of attitude assessment was needed for this study.

The "I" and "We" stems in this instrument were designed to capture several aspects of individual and group attitudes. The "I" questions dealt specifically with individual attitudes. They

were used as a reference point to gauge the responses to the "We" and "Other" stems. The question to be answered was whether there would be significant differences between an individual's attitude and his or her judgment of the attitude of the group. "We" items were constructed to capture "groupness". Would individuals be able to indicate a collective attitude and would this attitude be different from their own?

The theoretical underpinning for "Other" items comes from projective techniques of assessment. Projective assessment assumes that individuals will maintain positive personal qualities, and project negative qualities about themselves on to others around them. In this study, an attempt was made to determine if there is a difference between an individual's own attitude and the perceived attitude of others.

The final instrument, Individual and Group Attitudes Toward Science, consisted of 30 items. Twelve pertained to the student's own perceptions of the science classroom (i.e. "I think science is fun"). Another 9 assessed the student's perceived class attitude toward science (i.e. "We, the students, feel that science is worthwhile"). Finally, 9 assessed how the individual student saw other students' attitudes about science (i.e. "Other students like science more than I do"). Students responded to each question by marking an "x" along a 10 centimeter line between agree and disagree.

The second instrument, the Sentence Completion Test, asked

students to complete 20 open-ended questions such as "If I told my mother that I wanted to be a scientist, she would...." or "My friends think that science is...".

Results

Reliabilities and Validities

Although the Sentence Completion Test was developed primarily as a qualitative probe of attitudes toward science, it was desirable to cross-validate it with Individual and Group Attitudes Toward Science. Accordingly, a procedure was developed to quantify the results and yield a single score of attitude toward science. For the purposes of this analysis, three members of the research team independently coded each response for every subject as negative (1), neutral (2) or positive (3), and the three scores were averaged yielding a score for each subject of from 20 to 60. Inter-rater reliabilities were good, with perfect agreement in 81% of the cases and no more than one point of disagreement in 15%. Thus, only in four percent of the cases did raters disagree among themselves by more than one point.

Coefficient alpha for Individual and Group Attitudes Toward Science was 0.57, and for the Sentence Completion Test was 0.63. The coefficient of correlation between the two measures was 0.20.

Individual and Group Attitudes Toward Science

Factor analysis revealed four factors among items on this instrument (Table 1). The first and fourth are both interpreted as reflecting preference for science. However, the first contains a mixture of "I" and "We" items, while the fourth is predominantly composed of "I" items. The fourth factor appears to reflect individual attitude and the first is more of a projective measure of the respondent's perception of the attitude of the group. These are tentatively labeled Attitude: Self (Factor 4) and Attitude: Group (Factor 1).

The second factor contains items that mention work, pressure, difficulty, and preferred activities. It seems to reflect a perceived level of motivation and stress, and a need to do well in the face of pressure. A high level of agreement with this factor reflects a feeling that pressure for success exists, and perhaps provides a motivation for work. For this reason, it has tentatively been labeled Motivation: Extrinsic. The third factor contains items that reflect academic self-concept, including a subject's evaluation of performance of self versus others and a perceived evaluation by the teacher. It has tentatively been labeled Motivation: Intrinsic.

Factor scores on the Individual and Group Attitudes Toward Science measure were used in a three-way Analysis of Variance, with grade level x sex x classroom structure. There were significant grade level effects for all four factors, and

significant main effects and interactions for all variables on Factor 4 (Table 2).

Factor means on Factor 4, Attitude: Self, decreased from earlier to later grades (F=19.58, DF=3, p=.0001), from a high of .673 in the second grade to a low of -.396 in the eleventh grade. Means on Factor 1, Attitude: Group showed a similar decrease (F=69.62, DF=3, p=.0001), beginning with a nearly perfect .996 in the second grade, declining to a low of -.648 in the eighth grade, and rebounding slightly to a modestly negative -.102 in the eleventh grade (Figure 1).

In grades two and five, there are no differences between Attitude: Self (Factor 4) and Attitude: Group (Factor 1). However, by the eighth grade the two scores have separated, and there is a reversal of means between the eighth and eleventh grades (Figure 1). In the eighth grade, students express more positive personal attitudes (Factor 4) than they attribute to the group (Factor 1). In the eleventh grade they attribute more positive attitudes to the group (Factor 1) than they express for themselves (Factor 4).

Scores on Attitude: Self (Factor 4) also showed additional main effects and interactions. Students in student-centered classrooms had higher factor scores than those in teacher-centered classrooms (F=20.81, DF=1, p=.0001) and boys had higher scores than girls (F=10.77, DF=1, p=.001). There were significant interactions between grade and sex (F=2.67, DF=3,

p=.05) and between grade and classroom structure (F=3.80, DF=3, p=.01). These interactions show that, as grade increases the attitude of students in teacher-centered and and student-centered classrooms decrease and become more alike (Figure 2) and the gap in attitude between boys and of girls widens, with girls' attitude decreasing more rapidly than boys'(Figure 3).

There were significant main effects for grade level on Factors 2 (F=4.48, df=3, p=0.004) and 3 (F=4.71, df=3, p=.003), with a similar pattern. Mean factor scores on Motivation: Extrinsic (Factor 2) began and ended negative, with a slightly positive plateau in grades five and eight (Figure 4). Means on Motivation: Intrinsic (Factor 3) began and ended positive, with a minimum in the middle grades (Figure 4). Thus, students in second and eleventh grades felt little pressure or extrinsic motivation but were relatively secure about their own abilities. In the middle grades, increased pressure and desire for performance seems to have been coupled with a concomitant decrease in academic self concept and intrinsic motivation.

Sentence Completion Test

In order to analyze the results of the sentence completion test, the responses to each item were categorized. Chi-square analysis was then conducted for each question to see if there were significant differences in response frequency across sex, classroom structure and grade.

Four questions yielded a generalized picture of students' attitudes toward science. These were 20) "I think science...", 2) "My friends think science...", 5) "My mother thinks science...", and 18) "My father thinks science...". The highest frequency of positive response (83%) was on the first item. Although they themselves held almost universally positive attitudes toward science, students were evenly split on whether they thought their friends had positive (44%) or negative (43%) attitudes. They also attributed less positive attitudes to their fathers (45%) and their mothers (33%) than to themselves.

These items also yielded some interesting grade-level differences. On the first (20), 90% of the negative responses were from the 8th or 11th grades (chi-square=9.4, DF=3,p=0.02). On the second (2), 8th graders gave the lowest frequency of positive responses (chi-square=21.6, DF=4, p=0.000), and 8th and 11th graders gave the highest frequency of negative responses (chi-square=13.5, DF=4, p=0.009). On the third (5), 8th graders were most likely to give a neutral response (chi-square=9.9, DF=3, p=0.20) and on the last (18), they were least likely to believe that their fathers had a positive attitude toward science (chi-square=11.1, DF=3, p=0.011). There was a greater tendency for students in Student Centered Classrooms to believe that their father would have a positive attitude (chi-square=4.7, DF=1, p=0.030),

Item (6), "I feel that my science teacher...", yielded

information both about whether students liked the teacher and whether they thought s/he taught well. More liked the teacher (39%) than thought s/he taught well (29%), and more disliked the teacher (17%) than thought s/he taught poorly (9%). Among grades, students in the 11th were most likely to like their teacher (chi-square=34, DF=3, p=0.000) and say s/he was a good teacher (chi-square=34.3, DF=3. p=0.000), while those in the 8th were most likely to dislike their teacher (chi-square=8.7, DF=3, p=0.034). Those in Teacher Centered Classrooms were more inclined to dislike their teacher (chi-square=5.8, DF=1, p.=0.016) and to rate him or her as poor (chi-square=5.5, DF=1, p=0.019).

Four items, 11) "I wish my science teacher...", 3) "If I were in charge of a science group project, I...", 7) "In science, I am afraid of...", and 8) "What I want most out of this science class is...", yielded some information about preferences. Among these were more activities (32%), hands-on projects (25%), things that are fun (17%), things that are easier (16%) and less structured (7%). Those in Student-Centered Classrooms were especially anxious that there be more activities (chi-square=5.3, DF=1, p.=0.021). Students thought that their teacher should teach better (18%) and be nicer (10%). Half of the students were afraid of failing, and students in Teacher Centered Classrooms particularly felt that the teacher should be easier (chi-square=6.0, DF=1, p=0.015). What students wanted most from

the class were to learn (52%), to get a good grade (17%), to do activities (10%), and to have fun (9%).

Two statements, 12) "My feeling about science as a career is..." and 16) "I would like to learn more about science because in the future I..." revealed attitudes about careers in science. While 55% of the students responded that they needed information from science for their career, only 39% said that they would consider a career in science. Eighth graders were least likely to feel that they needed to study science in prepartion for a career (chi-square=10.1, DF=3, p=0.018). There is an unusual interaction between sex and classroom structure. Females in In Teacher Centered classrooms are less likely to say that they will not consider a career in science whereas boys are more likely to say that they will not.

Conclusions

This study replicates the results of three National Assessments, and reaffirms the depressing trend of a decline in attitude toward science from the early to the late school years. Second graders have almost universally positive attitudes, whereas the vast majority of of negative comments about science came from students in the eighth and eleventh grades.

An interesting pattern has been revealed with regard to the attitudes of "self" and "other". Students commonly attribute different attitudes to their peers than they claim for

themselves. In the earliest grades the differences are least, a fact that is highly consonant with the evidence from developmental psychology that younger children have difficulty separating "self" from "other". By the eighth grade, results of the Individual and Group Attitudes Toward Science measure and the Sentence Completion Test show the gap widening. The most prominent overall finding is that students express better attitudes toward science than they believe others hold, and better than those that they believe their parents hold. It is not uncommon for students to report that, although they enjoy an activity (e.g. dissections), most others do not. There are two major exceptions to this trend. Girls generally have a worse "self" attitude than boys but do not ascribe sex differences in attitude to "others". And, by the eleventh grade all students have lower "self" attitudes than they attribute to "others".

The nature of the classroom is a clear variable for "self" but not for "other". In all grades until the eleventh, students who perceive the locus of control to rest with themselves rather than with the teacher have better attitudes toward science. The personal characteristics of the teacher weigh more heavily with students than whether s/he is a good teacher or not. Among these, they wish the teacher would be "nice", and teachers are disliked most in the eighth grade and in teacher-centered classrooms.

It appears that the stress of school work peaks in the

middle grades, and with this come feelings of inadequacy. The phenomenon is one that has been described before, and has been considered an important element in motivation theory. Gage and Berliner (1992) cite a series of studies in which rewards were were followed by a drop in achievement. "It was as if the youngster's intrinsic motivation was somehow undermined by the reward" (pg. 352). Thus, when people perceive an increasingly salient extrinsic motivation, such as school-work and grades, their inherent intrinsic motivation and confidence in their ability to complete a task show a concomitant decline. The subsequent shift in the eleventh grade may reveal, at least in part, the results of self-selection by students out of science after they enter high school.

The Sentence Completion Test reveals classroom techniques that students value. They are anxious for more activities and hands-on projects, things that are easier and more fun, and a less structured classroom. In particular, students reveal the importance to them of divergence in goals and outcomes. They prefer open-ended lessons where a variety of results are tolerated over convergent ones where a single conclusion is allowed. They prefer the content to be less conceptually complex, without emphasis on terminology and theoretical or mathematical constructs.

The implications of these results are quite clear. There is little profit in educating students in the sciences if the result

is that they dislike it intensely and do not intend to continue in science classes or to pursue it as a profession. The tension in schools and for teachers is between striving to improve attitude or academic achievement, and the balance at the moment seems to lie with achievement. Whether this is an intentional or an accidental consequence is unclear, but there is virtually no evidence that schools are actively engaged in trying to improve students' attitudes.

Some solutions are relatively obvious. Students need to feel that the locus of control in the classroom is at least shared between themselves and the teacher. This would allow them, in all probability, to direct events in the classroom so that school work could become more cooperative and social, interactive and manipulative, less conceptually complex, more divergent and more relevant.

Another phenomenon that has become obvious through this and earlier studies is that there is little discussion of affect in classrooms and homes. One reason students know little about the attitudes of others is that they are never mentioned. Teachers do not ask the expression of feelings about science, nor do they inquire into the attitudes of students toward science as an activity or a career. Students seem equally uncertain how their parents feel about science, or whether they would be encouraged to pursue science as a career.

The results of our current educational system are tragic.

Whether students learn science or not, they come almost universally to dislike it. To continue such practices will only guarantee that they tune out and drop out. We need to improve attitude, and to do so will require changes that many will oppose. Nevertheless, it is imperative that we do so. The necessary changes can be made, and we must make them.

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Table 1: INDIVIDUAL AND GROUP ATTITUDES TOWARD SCIENCE
Factor Structure of the Instrument

Attitude:Group		Factor 1	2	3	4
1)	Science lessons are fun for me.	.68	.29	-.06	.01
2)	We (the students) see this science class as being worthwhile.	.64	.25	-.20	.23
4)	We (the students) feel that science is a waste of time.	.59	-.09	.03	-.08
6)	My friends are better at science than I am.	-.68	-.24	.02	.07
7)	I think other students in class like science more than I do.	.76	.10	-.06	-.03
8)	We (the students) take a positive attitude toward our science class.	.50	-.14	.19	-.23
9)	I feel pressure to do well in science class.	.63	.13	-.19	.12
10)	I get good grades in science.	.65	.22	-.08	.25
11)	We (the students) respect our science teacher.	.58	-.14	-.14	-.05
Attitude: Self					
3)	I would like to belong to a science club.	.03	.05	.03	.38
5)	I think other students' parents encourage them to do well in science.	.17	-.04	.15	-.32
12)	We (the students) would like the opportunity to get to work with everyone in this science class before the end of the school year.	-.29	-.20	-.05	.43
18)	I am better than other students in science.	.06	.19	.17	.54
19)	Most of the other students in my science class like science.	.04	-.28	.14	.51
25)	I would like to be a scientist someday.	.17	-.18	-.17	.27

Motivation: Pressure

13)	Scientists like music as much as other people.	.01	.57	-.01	-.23
14)	I don't like science lessons.	-.05	-.58	.32	.07
15)	We (the students) feel pressure to do well in this science class.	.12	.71	-.17	-.00
16)	Students prefer to work alone in this science class.	.03	.64	-.10	-.25
17)	I like science more than other students.	.13	.50	-.16	.31
20)	I like reading about science in books, magazines and newspapers.	.15	.67	-.35	-.02
21)	Other students would like me as a lab partner.	-.01	.18	.04	.01
22)	Our science teacher does not know what we like about science.	.10	.34	.20	.10
26)	Science is an easy subject for me.	.09	.56	-.04	.10
29)	We (the students) feel that science lessons should be fun.	.08	.49	-.04	.38

Motivation: Self-Concept

23)	We (the students) feel that science lessons are fun.	-.03	-.01	.60	.15
24)	Other students in my science class spend more time on their science homework than I do.	-.19	-.19	.63	.13
28)	My science teacher does not know what I like about science.	-.07	-.05	.66	-.06
30)	I think other students will make better scientists than I will.	-.16	-.03	.74	.01

Table 2.

INDIVIDUAL AND GROUP ATTITUDES TOWARD SCIENCE:
Mean Factor Scores of subjects by grade level

		FACTOR			
		I	II	III	IV
GRADE	2	.996	-.286	.289	.673
	5	.266	.083	-.148	-.089
	8	-.648	.170	-.163	-032
	11	-.102	-.112	.182	-.396

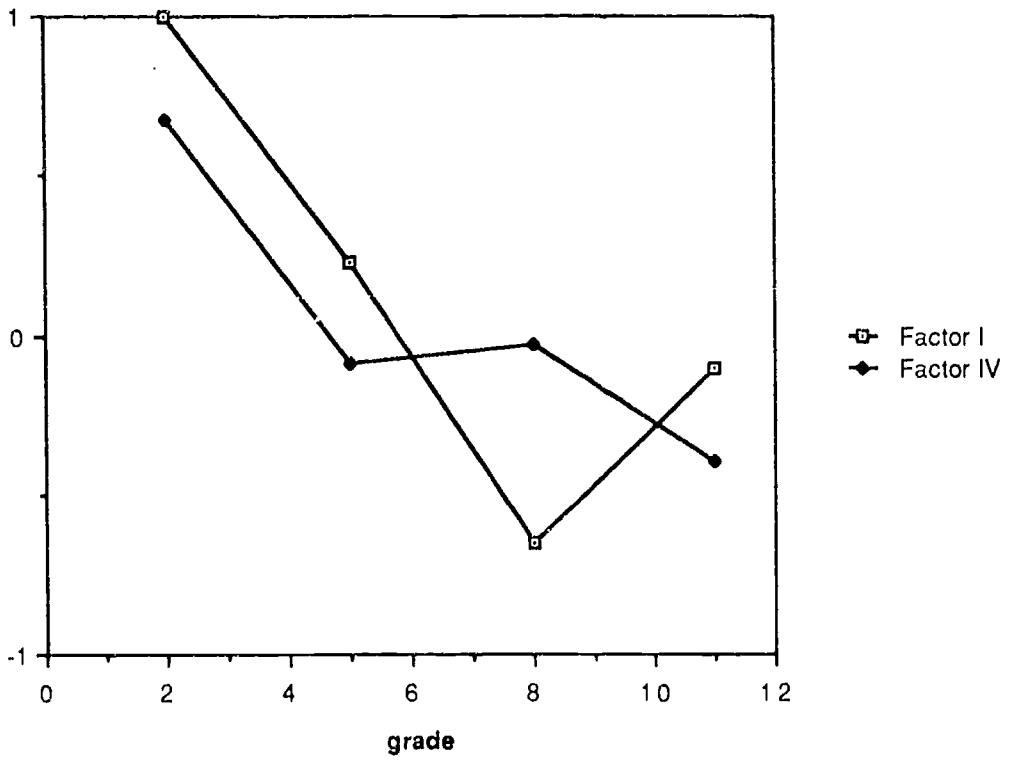

FIGURE 1: Mean factor scores of grades 2, 5, 8 and 11 for Attitude: Self (Factor I) and Attitude: Group (Factor IV)

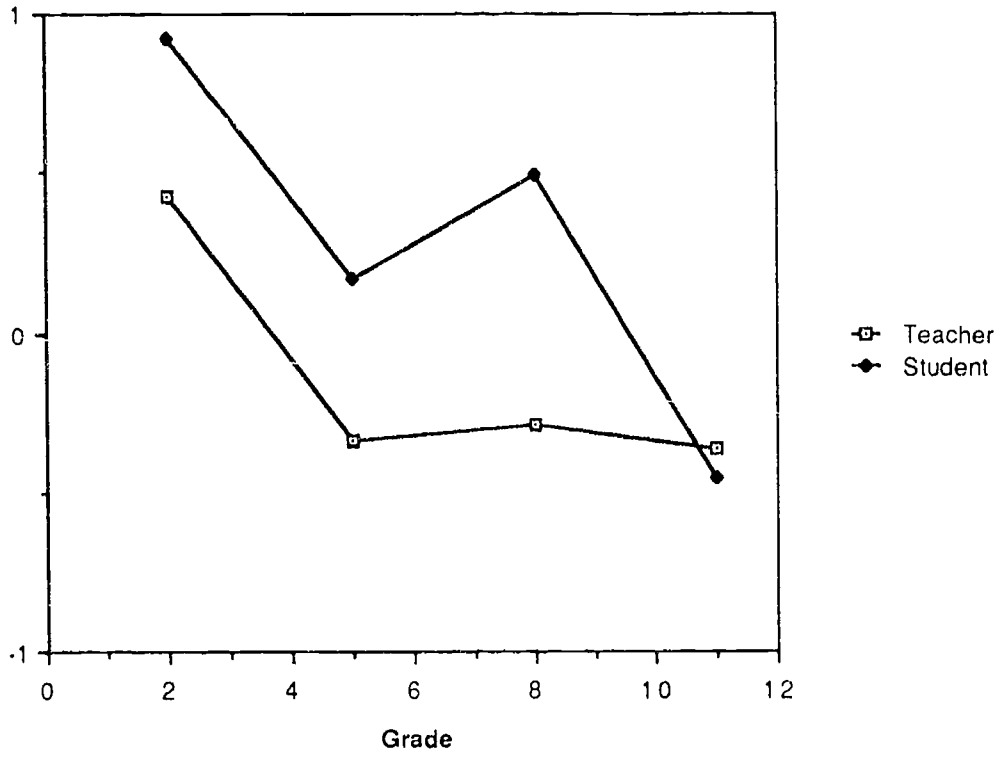

FIGURE 2: Mean factor scores of Student- and Teacher-Centered classrooms on Attitude: Group (Factor IV)

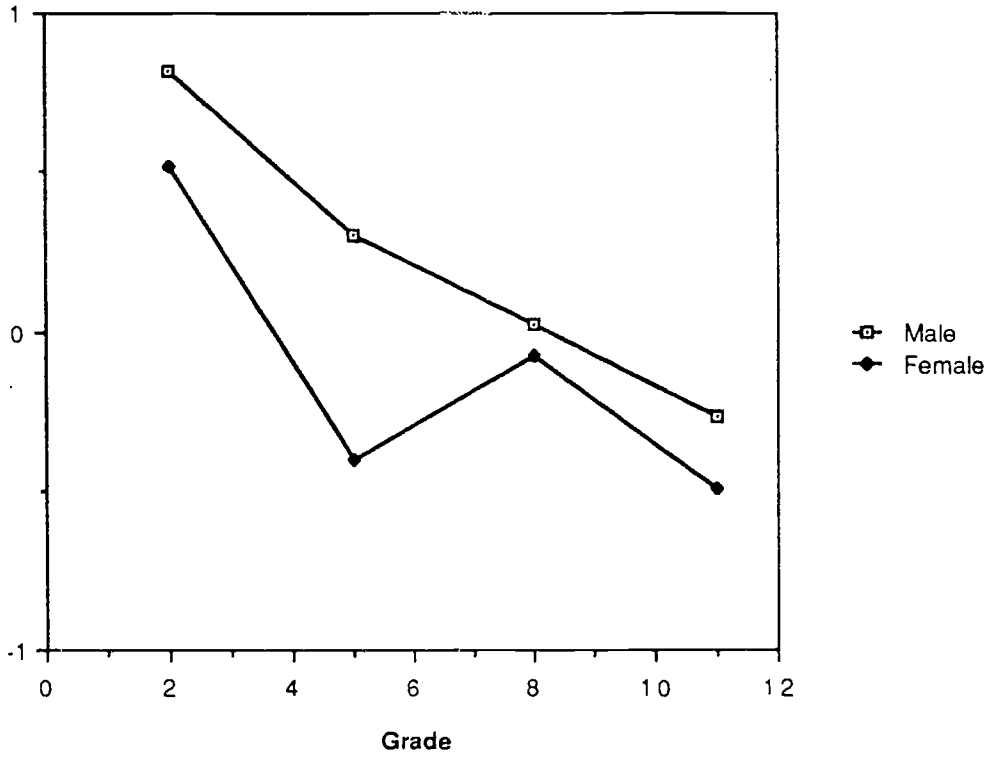

FIGURE 3: Mean factor scores of Males and Females on Attitude: Group (Factor IV)

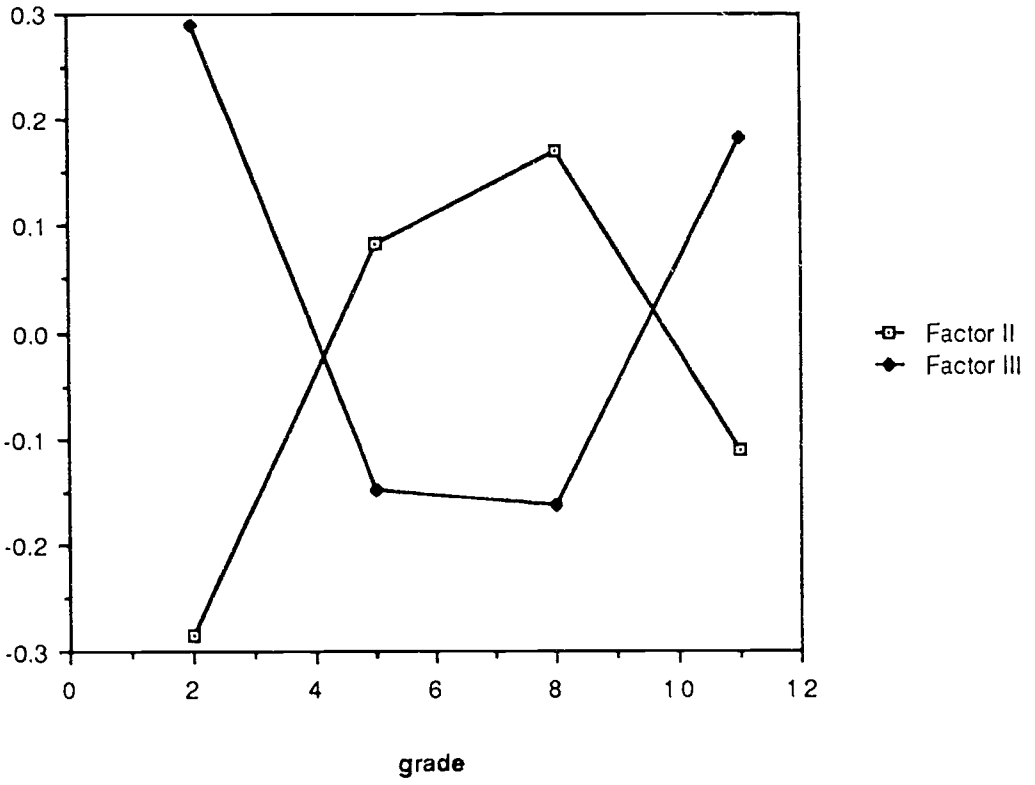

FIGURE 4: Mean factor scores of grades 2, 5, 8 and 11 for Motivation: Extrinsic (Factor II) and Motivation: Intrinsic (Factor III)